Exploration Research and Technology Programs

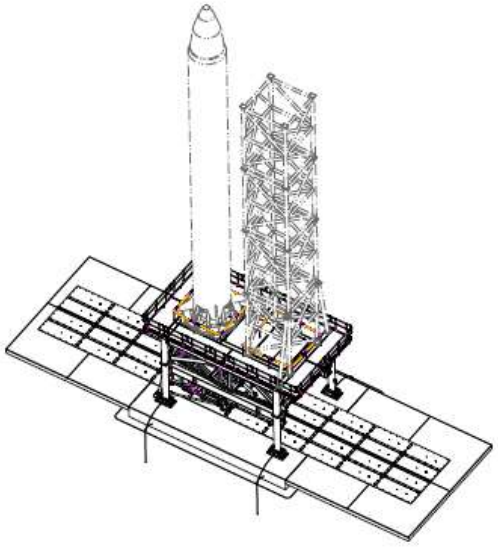
Launch Pad in a Box

James Mantovani
Gabor Tamasy,
Rob Mueller,
Van Townsend,
Jeff Sampson,
and Mike Lane
NASA Kennedy Space Center
Granular Mechanics and Regolith Operations Laboratory

SWAMP WORKS
NASA KENNEDY SPACE CENTER

ASCE Earth and Space
Engineering for Extreme Environments
April 11 - 15, 2016 | Orlando, Florida

DEPLOYABLE LAUNCH SYSTEM (DLS)

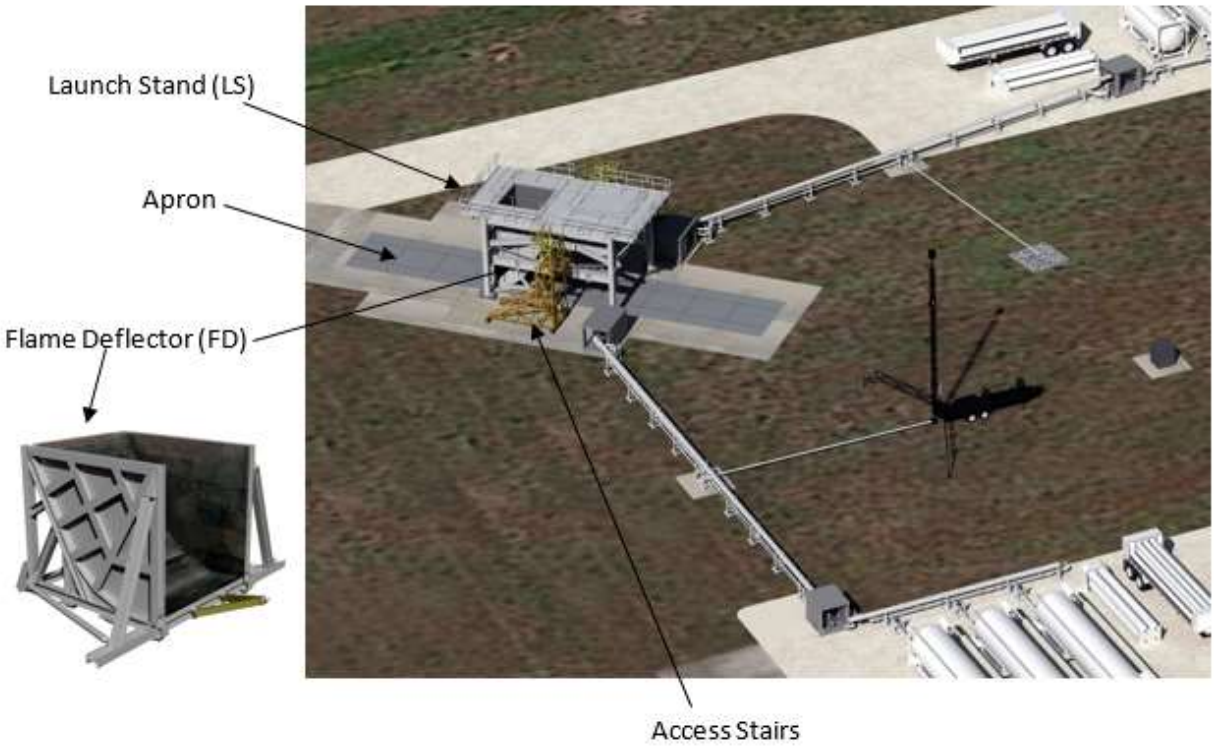


Modular Transportable Launch Platform

NASA KSC designed and partially built a new multi-user, modular and transportable rocket launch pad to provide a very flexible and low cost launching system for testing small to medium class rockets.

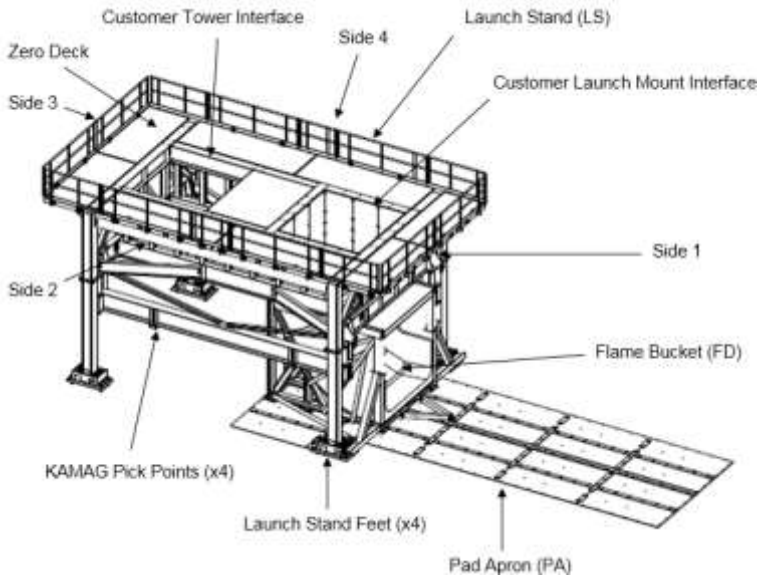
DLS Partnering Opportunities: http://kscpartnerships.ksc.nasa.gov/

DEPLOYABLE LAUNCH SYSTEM (DLS)



Not site specific, the DLS uses a bolted construction with components designed to fit on flatbed trucks and transported to any site, thus the name "Launch Pad in a Box."

DEPLOYABLE LAUNCH SYSTEM (DLS)

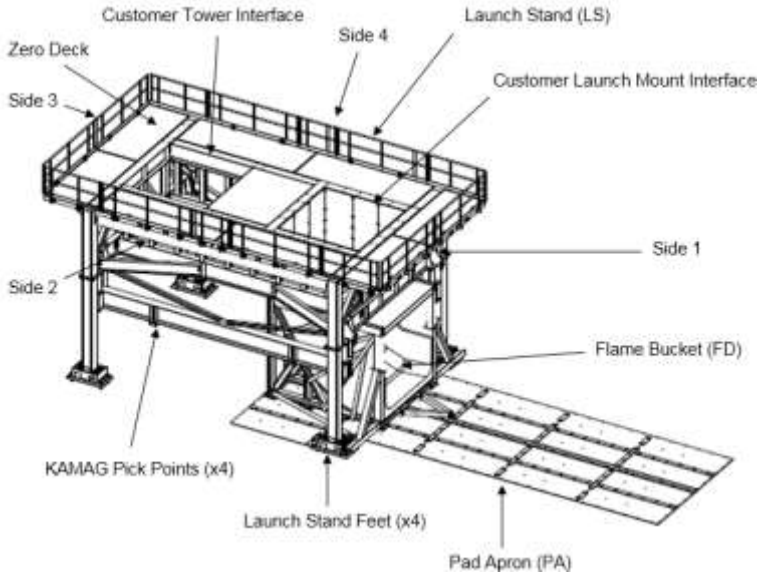


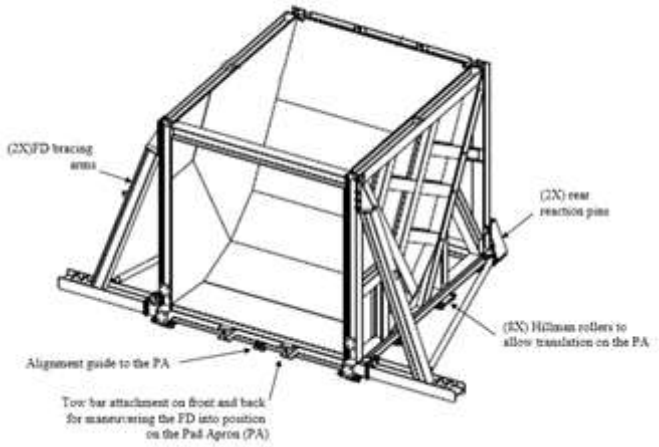
THE LAUNCH STAND (LS)

The LS is the central support structure to which the rocket and tower are attached and positioned for launch.

The LS design is based on the time proven mobile launcher platform concept that can move the rocket/tower “stack” to and from the launch pad and assembly/processing facility.

DEPLOYABLE LAUNCH SYSTEM (DLS)





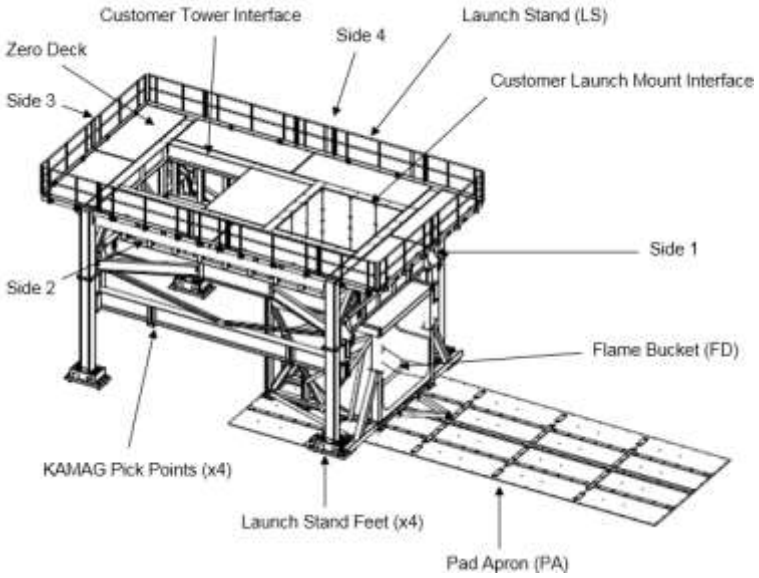
THE FLAME DEFLECTOR (FD)

The FD (or “flame bucket”) makes the DLS a fully functioning launch system.

The design of the DLS FD is unique in fitting the overall mission profile of the system. Unique features include: it’s modular and transportable, it’s above ground, mobile on wheels, and it can be used for launching or long duration “hot fire” testing.

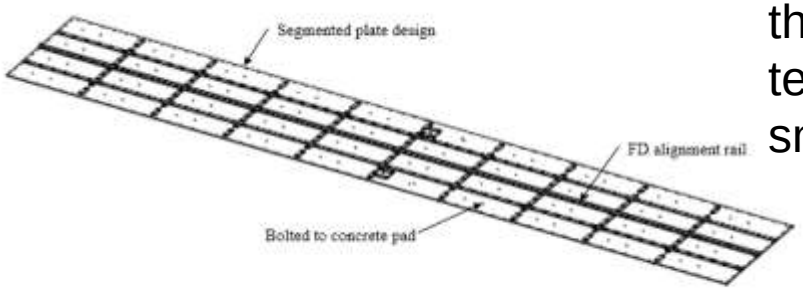
An optional layer of Fondu-Fyre on the hot wall improves the thermal characteristics to allow extended run times during hot-fire tests.

DEPLOYABLE LAUNCH SYSTEM (DLS)



THE PAD APRON (PA)

The PA is an integral part of the DLS and serves multiple functions.



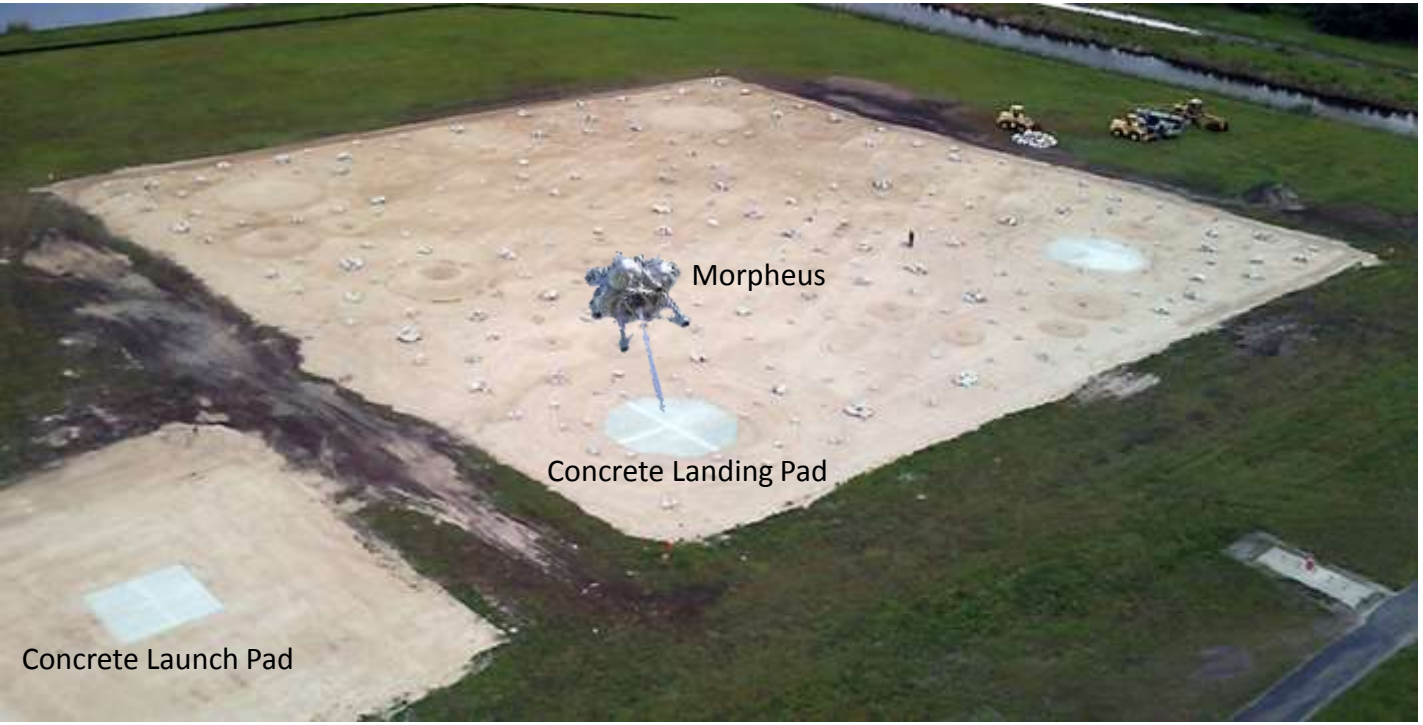
The PA's primary function is to protect concrete pads from the plume impingement heat damage that often results from a rocket exhaust's high temperature and velocity, and to provide a hard smooth surface for the FD to roll on.

DEPLOYABLE LAUNCH SYSTEM (DLS)

To summarize, the DLS as described above is truly a “Launch Pad in a Box” and introduces an innovative design solution for launching small to medium class rockets. Its modularity and ease of reconfiguring its components can meet the needs of any customers while providing an efficient and cost-effective launch structure.

TRANSPORTABLE MODULAR LAUNCH PADS AND LANDING PADS FOR VTVL VEHICLES

KSC performed several tasks related to studies of rocket plume effects for the JSC Morpheus Lander's free flight tests at a Hazards Field located adjacent to the KSC Shuttle Landing Facility.

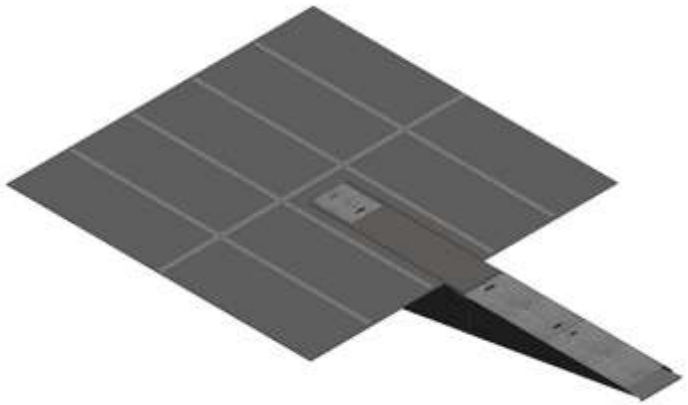


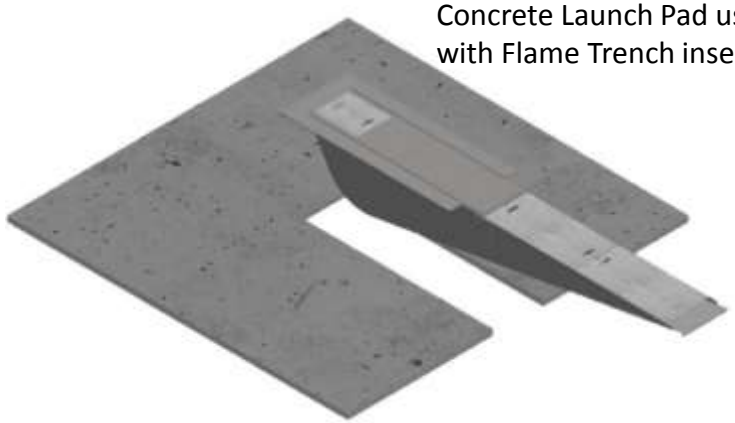
Morpheus VTVL Testbed using LOx/Methane

MORPHEUS

TRANSPORTABLE MODULAR LAUNCH PADS AND LANDING PADS FOR VTVL VEHICLES

KSC studied thermal ablatives applied to the interior of a steel flame trench that KSC designed, and then monitor the ablatives following each launch. The second task was to study the erosion of concrete following the landing of the Morpheus vehicle on a concrete landing pad.





Concrete Launch Pad used by Morpheus with Flame Trench inserted into slot

A steel flame trench designed at KSC is able to be inserted into either a modular steel launch/landing pad (left), or a concrete launch pad (right). Both pads are transportable.

TRANSPORTABLE MODULAR LAUNCH PADS AND LANDING PADS FOR VTVL VEHICLES

THE VTVL FLAME TRENCH

The Flame Deflector portion of the Flame Trench was coated with trowable silicone ablatives

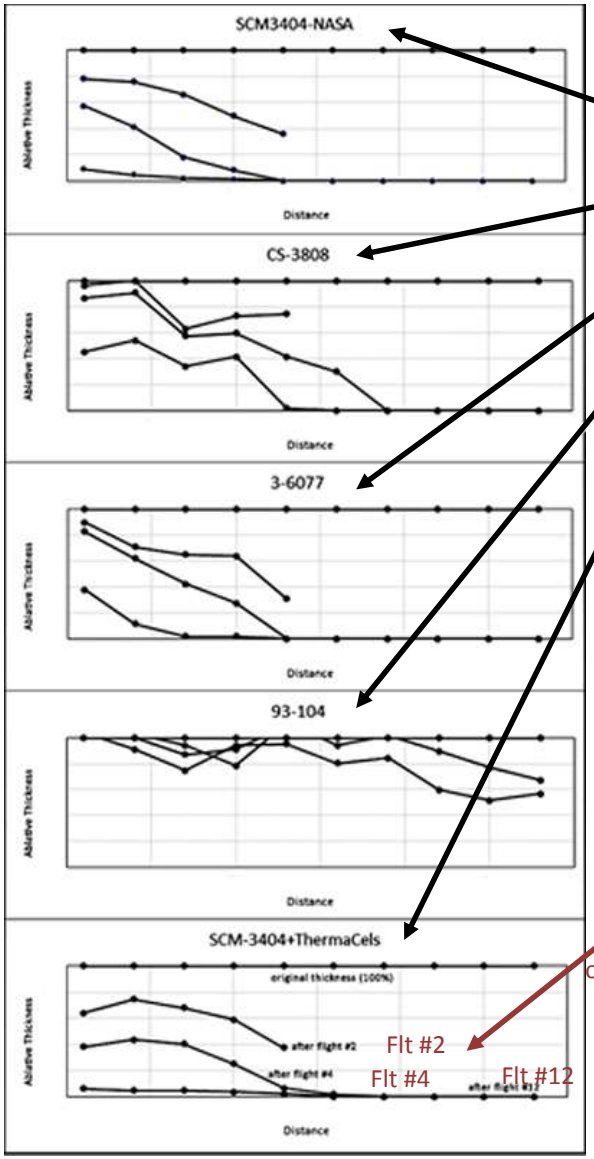
Commercially available products consisted of the following:

A. Momentive SCM-3404-NASA, 1-part coating, applied by brush
B. Chem Seal CS-3808, 2-part trowable ablative coating
C. Dow Corning 3-6077, 2-part trowable ablative coating
D. Dow Corning 93-104, 2-part trowable ablative coating
E. Momentive SCM-3404-NASA with 30% by wt Hy-Tech Thermal Solutions ThermaCels

All other surfaces of the Flame Trench were coated with Momentive SCM-3404-NASA

The ablative coating types (ABCDE) were applied to inorganic zinc paint inside the steel flame trench.

TRANSPORTABLE MODULAR LAUNCH PADS AND LANDING PADS FOR VTVL VEHICLES



Percentages of original ablative materials remaining after **2, 4 and 12** Morpheus free flights as measured at given distances from the top of the flame trench.

original thickness

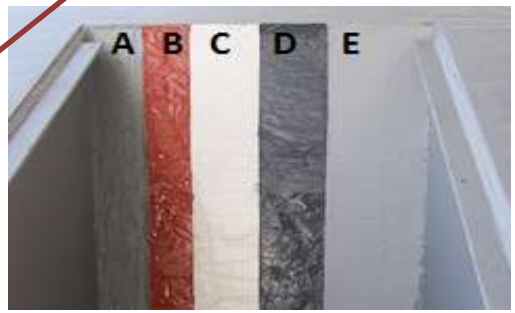
Flt #2

Flt #4

Flt #12

Thermal Ablatives applied to the interior of the Flame Trench

A. Momentive SCM-3404-NASA, 1-part coating, applied by brush
B. Chem Seal CS-3808, 2-part trowable ablative coating
C. Dow Corning 3-6077, 2-part trowable ablative coating
D. Dow Corning 93-104, 2-part trowable ablative coating
E. Momentive SCM-3404-NASA with 30% by wt Hy-Tech Thermal Solutions ThermaCels



Ablative coatings inside the steel flame trench.
(Left) Original ablative coatings.
(Right) Ablative coatings after twelve Morpheus free flight launches.

TRANSPORTABLE MODULAR LAUNCH PADS AND LANDING PADS FOR VTVL VEHICLES

During the descent and landing of the Morpheus lander on a concrete landing pad, a volume of concrete was eroded by spalling after each landing. After ten landings, it was estimated that a cumulative volume of 0.11 cubic meters of concrete had been eroded.

Original condition of concrete landing pad used during descent and landing of the Morpheus lander

Physical state of the concrete landing pad after ten free flights.

TRANSPORTABLE MODULAR LAUNCH PADS AND LANDING PADS FOR VTVL VEHICLES

To summarize, KSC has demonstrated an innovative and cost-effective design solution for launching and landing VTVL vehicles on modular pads. Its modularity and transportability can meet the needs of any customers needing to conduct free flight testing at a hazards field.

CONCLUSIONS

We have described a new deployable launch system (DLS) capability developed at NASA Kennedy Space Center to support government and commercial small-class launch vehicles. We have also presented a transportable modular launch/landing pad concept and modular flame trench to support free-flight testing of vertical takeoff, vertical landing (VTVL) vehicles.

SWAMP WORKS

https://www.facebook.com/SwampWorksKSC

For information about teaming up with the GMRO Lab at KSC, contact:

Khoa Vo (khoa.a.vo@nasa.gov)
or Rob Mueller (rob.mueller@nasa.gov)

SWAMP WORKS
NASA KENNEDY SPACE CENTER